

Ocean Surface Currents in the Classroom

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Abstract—The Ocean Motion web site (<http://oceanmotion.org>) provides classroom ready materials for high school teachers and students to investigate ocean surface currents. The story of humankind's interest in surface currents has an adventuresome background in early seafaring and exploration and their patterns of movement impacts the weather, climate, commerce natural disasters and sea life. Lesson one encourages students to learn why Columbus landed in the Caribbean and not New York City and how Captain Bligh survived the mutiny on the Bounty. Satellites that monitor the sea surface environment are emphasized. Investigate a multi-year record of global data for sea surface temperature, height, winds, and ocean color. These global data are made available to teachers and students through an easy-to-use interface. The range of topics covered by the Teacher and Student Guides, their stand-alone style and focus on traditional science concepts will promote their use in traditional science and mathematics classrooms.

I. INTRODUCTION

The purpose of the Ocean Motion project is to empower students to become aware and take care of Earth's ocean, while developing and practicing skills recognizing patterns in data and models that serve to explain and predict.

The ocean is remote and vast. Lack of information about the ocean's changing state make it difficult for the public as well as classroom teachers to observe and study ocean dynamics. In spite of the fact that the ocean covers 72% of Earth's surface, most instruction time in the Earth science classroom is devoted land surface topics.

The ocean has played a major role in the history of human civilizations, explorations and commerce makes the ocean surface environment an exciting environment linked to exploration and adventure. The scientific study of ocean surface currents provides numerous connections to traditional topics studied in history, geography, biology, chemistry, mathematics and physics. Study of the ocean surface is also of great relevance for social, economic and humanitarian as well as scientific reasons. Ocean and atmospheric circulation interact to play an essential role in sustaining life by moderating climate over much of Earth's

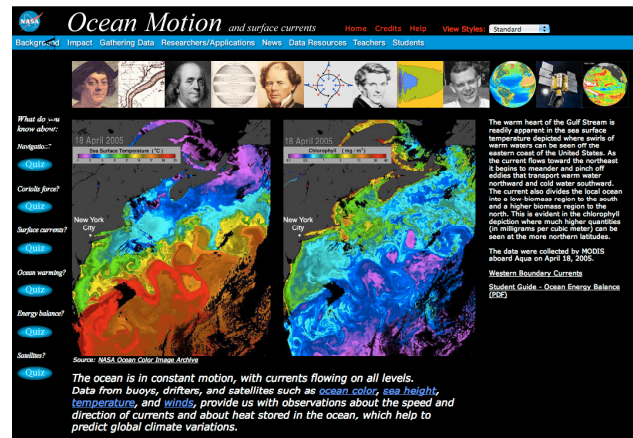


Figure 1. The Ocean Motion homepage.

II. THE WEB SITE

A. Content overview

The site features a toolbox of satellite and model data, quick evaluation quizzes and a timeline of ocean exploration to inspire investigation of ocean surface current patterns and how they relate to issues of navigation, commerce, weather/climate, and natural hazards. Classroom ready lessons help high school students practice skills matched to national standards, which are keyed to topics covered in traditional high school curriculum and to the stages of the 5 E's teaching and learning model.

Project resources in support of the Ocean Motion web site are; • five video scientist interviews and profiles describing their research and career paths, • Remote sensing data products (images, time series graphs, and tables of satellite data) created to be conveniently accessible in the classroom, • fifteen interactive satellite data visualizers and models integrated with the 6 classroom lessons, • emphasis on mathematics, basic statistics and models to bridge the gap from data to quantifying patterns and testing hypotheses, • six student lessons and teacher's guides organized on the five E teaching/learning model, • keys to science standards (AAAS 1993, NRC 1996), ocean literacy and traditional classroom topics.

The

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B. Section 1: Background

Text and illustrations in the Background section of the web site is derived from the American Meteorologic Society's *Data Streame Ocean*. The content includes descriptions of Patterns of Circulation, Vertical Structure, Wind-Driven Currents and Ekman Transport, Geostrophic Flow, Gyres, Equatorial Currents, Western Boundary Currents, Rings, Upwelling, Downwelling and the Ocean Conveyor Belt. NASA satellite data images are included to support the text and illustrations.

C. Timeline


Beginning with the Egyptians in 3200 B.C. through present day satellites, human use and observation of ocean surface currents is outlined in an easy to use interactive interface.

D. Impact

Three Articles written and reviewed by the scientific community describe the importance of ocean surface currents to human life through the issues of the day including, Climate Variability, Natural Hazards and Marine Resources.

E. Scientist Interviews and Profiles

Interviews with scientists who study ocean surface currents are provided to illustrate the connection between the study of science questions and the human experiences, interests and emotions that affect and motivate individuals. The intent is to inform students about the scientist's field of research as well as to encourage students to pursue careers in ocean science and technology. In each interview, scientists discuss not only their research but also recount important experiences and influences in their own career paths. Many students are not familiar with ocean-related careers, unless they live near the ocean, and few have any contact with practitioners who have invested much of their life in measuring and understanding the ocean and its interactions. The scientists selected for interviews study ocean surface currents and work with satellite as well as in-situ data. The video clips are captioned and posted in two formats on a video server.



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Not all oceanographers have their perspectives on the ocean shaped by experiences at sea. Take Kathryn Kelly. She does not venture out on a ship, dive in a submarine, or even go to the beach to conduct her research. Instead, she experiences the ocean through satellite images and numbers on her computer. While she may miss out on the excitement of a life on the open ocean, the copious amounts of data at her fingertips more than make up for it. For Kathryn, having enough data to pursue important questions about the ocean is what research is all about.

Up until a decade ago, oceanographers had to go out to sea to measure parameters such as temperature, wind, and currents. These measurements were time-consuming, expensive, and infrequently repeated; therefore it was impossible to compare these parameters from year to year. Now Kathryn receives satellite images from NASA containing this information every ten days. One satellite instrument called an altimeter detects currents by measuring horizontal differences in sea surface height. Changes in sea surface height can indicate the amount of heat in the ocean because the ocean expands when it is heated and contracts when it is cooled. So if you look downstream along a warm-water current, such as the Gulf Stream, the sea height on the right is higher (warm water) and the sea height on the left is lower (cool water). The altimeter measures sea surface height by bouncing radar signals off the ocean and timing their echo. They have an accuracy of three centimeters—an amazing number considering that the satellites are 1,300 kilometers high.

These satellite data are helping Kathryn gain insights into how the ocean influences the climate. At the simplest level, the ocean acts as a heat reservoir. It absorbs heat from the atmosphere when the atmosphere is warmer and releases heat to the atmosphere when the atmosphere is cooler. This transfer of heat between the ocean and atmosphere is called heat flux. The reality, however, is more complicated. Ocean currents redistribute the heat around the world by carrying warm water from the equator towards the poles. For example, the Gulf Stream moves huge amounts of warm water from the tropics up along the east coast of North America and across to northern Europe. The presence of this warm water in the North Atlantic helps explain why Scotland has a relatively mild climate when compared to places at similar latitudes in North America such as Churchill, Manitoba—a Canadian town famous for its seasonal polar bear population.

Shown above are tracks (or paths) of buoys drifting at sea (green), and tracks of the TOPEX/Poseidon satellite (blue). Study region is marked by red rectangle.

A second satellite instrument called a scatterometer enables Kathryn and her colleagues to calculate wind stress. The satellite sends down a pulse and measures how much it is scattered by ripples and waves created by wind stress. (Think about how wind creates ripples on a pond.) Unlike instruments that just measure air speed, the scatterometer measures the movement in air relative to the movement of water. For example, if the wind was blowing at the same speed and direction as a current, it would create no stress on the water and there would be no ripples. Wind stress is an important factor in determining the transfer of heat between the ocean and atmosphere.

Figure 2. Dr. Kathryn Kelley Interview and Profile.

F. Interactive Visualizers

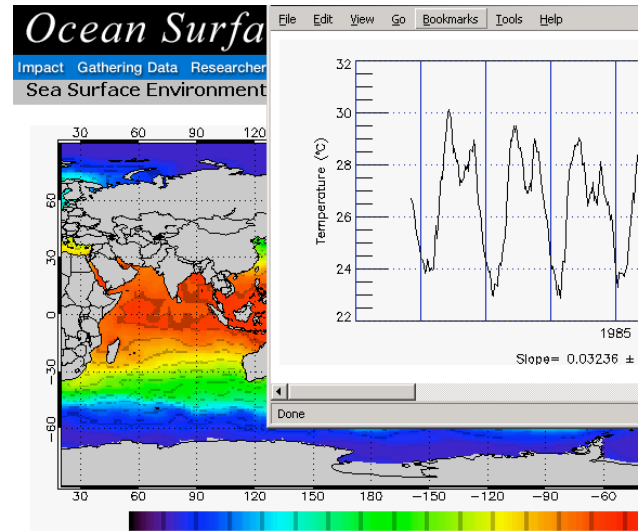


Figure 4. Sea Surface Environment Visualizer.

The remotely sensed, global ocean data is made available through interactive visualizers that use drop-down menus, click-on image maps and popup windows to present data products (time-series graphs, data tables and data-overlaid-on-map images). Many of the visuals are produced beforehand (and updated regularly) to minimize access and processing time. In the school environment, a quick, efficient response is judged important for classroom data investigations. At the suggestion of teachers, we have taken data from various satellite platforms and have reformatted it to be accessible through the same user interface. Through the student investigations, students are introduced to various common statistical measures and operations on data appropriate to the high school level. For operations with real data, the students are provided with a data calculator that takes much of the tedium and mistakes out of computation work. It is important in some of the investigations that the students can extract quantitative measures and gather "hard" evidence to support or reject possible alternative hypothesis [Chamberlin T. C., 1931].

III. CURRICULUM MATRIX AND THE FIVE E'S MODEL

An important component of the project is the teacher and student guides. Student Investigations organized our student investigations following the Five E teaching/learning cycle [Trowbridge, L. W. et. al., 1990], and provide a teacher matrix, which ties the "Impact" concepts of the web site to the student investigations. The impact themes head each column in the matrix and include; Weather/Climate variability, Marine Resources, National Security, Natural Hazards, Navigation and Pollution. The horizontal rows of the matrix clarify concepts and

define tasks that illustrate how the investigations may be used in the classroom. A sample of the row concepts include; Enduring Understanding, Essential Questions, Knowledge and Skills, Performance Tasks, Science Standards, Ocean Literacy Key Concepts, Model Building, and Student Investigations.

In recent years, cognitive scientists and science educators have focused on the constructivist model of learning. Constructivism, views human learning, as an outcome of a dynamic, interactive process. In the constructivist model, students reconstruct core concepts, or intellectual structures, through continuous interactions within themselves and with their environment, including other people. Through these interactions, students redefine, reorganize, elaborate, and change their initial concepts. A students' construction of knowledge can be assisted by using sequences of lessons designed to challenge current conceptions and provide time and opportunities for reconstruction to occur. A number of different models of instruction are conducive to fostering a constructivist approach in the classroom. Among them is the 5 E's model (Engagement, Exploration, Elaboration, Evaluation). The following sections summarize the five phases (5E's) of this instructional model as defined by Trowbridge and Bybee in 1990.

Engagement

The first phase (the first E) is designed to actively engage the student in the learning task. The student mentally focuses on an object, problem, situation, or event that can be related to the world of the learner. Asking an authentic question, defining a real problem, showing a discrepant event, and acting out a problematic situation are all ways to engage students and focus them on the instructional task. The role of the teacher is to present the situation and identify the instructional task. The teacher also sets the rules and procedures for establishing the task. Successful engagement results in students being puzzled by, and actively motivated in the learning activity.

Exploration

Following the engagement phase, students have psychological need for time to explore the ideas. Exploration (the second E) activities are designed so that students have common, concrete experience upon which they continue building concepts, processes, and skills. Engagement brings about disequilibrium; exploration initiates the process of restoring equilibrium. The aim of exploration activities is to establish experiences that teachers and students can

use later to formally introduce and discuss concepts, processes, or skills. During the activity, the students have time in which they can explore objects, events, or situations. The teacher's role in the exploration phase is that of facilitator or coach. The teacher initiates the activity and allows students time and opportunity to investigate objects, materials, and situations based on each student's own ideas of the phenomena.

Explanation

The "explanation" (the third E) means the act or process through which concepts, processes, or skills become plain, comprehensible, and clear. The process of explanation provides the students and teacher with a common use of terms relevant to the learning task. In this phase, the teacher directs student attention to specific aspects of the engagement and exploration experiences. First, the teacher asks students to give their explanations. Second, the teacher introduces scientific or technologic explanations in a direct and formal manner. Explanations are ways of ordering the exploratory experiences. The key to this phase is to present concepts, processes, or skills briefly, simply, clearly, and directly and move on to the next phase.

Elaboration

Once students have an explanation of their learning tasks, it is important to involve them in further experiences that elaborate (the fourth E) on the concepts, processes, or skills. In some cases, students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. Elaboration activities provide further time and experiences that contribute to learning. Typically, elaboration activities are interdisciplinary in nature and involve reading, writing, mathematics, and social studies.

Evaluation

At some point, it is important that students receive feedback on the adequacy of their explanations. Informal evaluation (the fifth E) can occur from the beginning of the teaching sequence. The teacher and student can complete a formal evaluation after the elaboration phase. As a practical educational matter, teachers must assess educational outcomes. This is the phase in which teachers administer tests, read student journals, and audit group interactions to determine each student's level of understanding. This is also an important opportunity for students to use the skills they have acquired and evaluate their understanding.

CONCLUSION

The Ocean Motion website is under evaluation by NASA and we plan to add three more “impact areas” to help teachers convey to students the biological, meteorological, climatological and economic significance of ocean surface currents.

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